timber, such, for instance, as making alcohol from wood waste; in addition, Products is gathering much statistical information of use not only to the Forest Service, but to all wood-using industries. Products comes in closer contact with the lumber industry than any other branch of the service and has already secured results of great value to lumbermen. Under Silviculture, the *Review* gives in some detail the important problems on which the service is working. It describes briefly the establishment and purpose of the experiment stations; under each head (forestation, forest influences, management, etc.) it not only gives the problems to be studied, but shows their importance and their relation to each other. The experiment being conducted at Wagon Wheel Gap to determine the influence of forest cover on run off and erosion is given rather fully. This is probably the most complete and far-reaching experiment of its kind in the world.

At the end of the *Review* is the investigative program for 1912. A study of this program will show the thoroughness with which the field is being covered.

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SPECIAL ARTICLES

A LABORATORY METHOD OF DEMONSTRATING THE EARTH'S ROTATION

THE two laboratory methods in general use for proving the rotation of the earth are Foucault's pendulum and gyroscope experiments. The first is inapplicable in many laboratories, because there is no convenient place to hang a sufficiently long and heavy pendulum, while the apparatus for the second is necessarily expensive. The following experiment is designed to provide a simple and convenient means by which the earth's rotation may be demonstrated in a small laboratory. The demonstration depends upon the fact that, if a circular tube filled with water is placed in a plane perpendicular to the earth's axis, the upper part of the tube with the water in it is moving toward the east with respect to the lower part. If the tube is quickly rotated through 180 degrees about its east and west diameter as an axis, the part of the tube which was on the upper side attains a relatively westward motion as it is turned downwards (since it is drawing nearer the earth's axis). But the water in this part of the tube retains a large part of its original eastward motion, and this can be detected by suitable means.

Since the east and west axis itself is rotating with the earth, only that component of the water's momentum which is parallel to this axis will have an effect in producing a relative motion when the tube is turned. If then a is the angular velocity of the earth's rotation, r the radius of the circle into which the tube is bent, and θ the angular distance of any small portion of the tube from the east and west axis, the relative velocity between the water and the tube when it is quickly turned from a position perpendicular to the earth's axis through 180 degrees is

$$\text{Velocity} = V = \frac{ar}{\pi}\int_0^{2\pi} \sin^2 \theta d\theta = ar.$$

In order to prevent convection currents, it is best to hold the ring normally in a horizontal position, in which case the relative motion is of course $ar \sin \phi$, where ϕ is the latitude of the experimenter.

To perform the experiment, glass tubing 1.3 cm. inside diameter was bent into a circular ring 99.3 cm. in radius, and a short glass tube closed with a rubber tube and screw clamp was sealed into it to allow for the expansion of the water and to provide a place for filling. The ring was fastened with tape into notches in the wooden rod A (Fig. 1), which served as the horizontal axis, and was

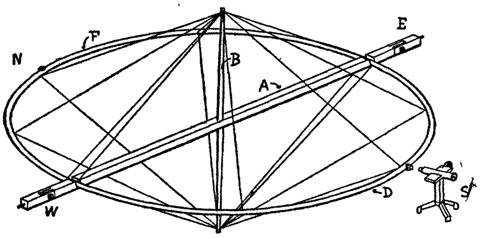

FIG. 1

supported by wires from the extremities of the cross rod *B*. The ends of the rod *A* were made adjustable perpendicularly to the plane of the ring, so that the ring might be made to swing on an axis parallel to its plane. The ends of the rod were swung in solid supports, adjustable to make the axis horizontal. In order that the motion of the water might be detected, a mixture of linseed oil and oil of cloves of the same density as water was prepared, and a few drops of the mixture were shaken up with the water with which the tube was to be filled. The globules of oil were observed at a point *C*, between the ends of the axis, through a micrometer microscope. Difficulties from the astigmatic refraction of the light by the water in the cylindrical glass tube were overcome by sealing a tubular paraffine cap, closed with a cover-glass and filled with water, on the part of the glass tube under the microscope, thus presenting a plane surface through which to make the observation. One side of the ring was weighted, so that on releasing a catch at the side of the observer the tube swung around through 180 degrees in a definite time, and was held again by the catch just under the microscope.

In taking a reading, the microscope was focused as nearly as possible on the center of the tube, and the ring was left in position until the oil globules had no appreciable motion. As soon as the catch which held the ring in position was released, the time was counted, with the aid of a metronome ticking half-seconds, until the tube had turned and an oil globule had been fixed upon to follow. The globule was followed through a measured length of time by turning the micrometer screw, and the distance through which it moved was recorded. Examples of these observations are given in the first three columns of Table I.

Variations in the readings arose from the fact that the part of the ring toward the east was near a cold wall, so that convection currents were produced as soon as the tube left the horizontal position in making a turn. This effect was made as small as possible by stirring the air with an electric fan. Other variations came from the fact that it was found impossible to adjust the horizontal axis so nearly parallel to the plane of the ring as to prevent a slight effect from turning the tube. Errors from the first cause were corrected by reversing the direction of turning in alternate readings. Those from the latter cause were nullified by taking readings with one side of the ring weighted and then shifting the weight to the other side. In this manner ten readings of each of four different kinds were taken (Cases I., II., III. and IV.), and the fact that the predominant motion is positive, or toward the west as observed on the south side, shows that the earth is turning from the west to the east.

TABLE I

Time from Releasing Catch to Following Water's Motion	Time of Following Water's Motion, Sec.	Distance Through which Water is Followed, Mm.	Time from Completion of Turn to Following Water's Motion, Sec.	Time on Curves of Completion of Turn	Initial Velocity, V, Mm. Sec.$^{-1}$
Case I. Weight on side *D*. Change from heavy to light side.					
7.5 secs.	22.5	+ .40	4.5	+21.2	+.041
7.0	23.0	+ .37	4.0	+22.1	+.03[illegible]
Case II. Weight on side *D*. Change from light to heavy side.					
7.5	22.5	+1.57	4.5	− 1.0	+.160
8.0	22.0	+1.35	5.0	+ .5	+.155
Case III. Weight on side *F*. Change from heavy to light side.					
8.0	22.0	− .59	5.0	+13.4	−.067
7.5	22.5	− .70	4.5	+11.4	−.075
Case IV. Weight on side *F*. Change from light to heavy side.					
7.5	22.5	+ .37	4.5	+19.9	+.045
8.0	22.0	+ .67	5.0	+11.5	+.075

Average V: Case I. = .0434; Case II. = .1580; Case III. = − .0633; Case IV. = .0671.

Calculation of the Initial Velocity

In order to make an accurate estimate of the velocity corresponding to any given reading, the rate of decrease of velocity of the water in the ring must be determined. If the retardation r is taken to be proportional to the velocity V for this low velocity,

$$r = \frac{dV}{dt} = CV,$$

$$\frac{dV}{V} = Cdt,$$

and

$$\log V = Ct + K$$

will express the value of the velocity at different times. In order to determine the constants C and K, the ring was held in a vertical position until the colder water near the east wall produced a considerable motion. It was then brought back to the horizontal and the time observed which was required to move successive quarter millimeters. A few such readings are given in Table II. From a large number of such observations an average curve was drawn, showing the relation of the distance covered to the time (Fig. 2, Curve *A*). The slope of this curve was taken at two of the most definite points, $t = 12.5$ and $t = 30$, and these values were substituted in equation (1) to determine the constants C and K. The curve in Fig. 3 was then drawn from the resulting formula, showing the velocity at any time. Curve *B*, Fig. 2, was then constructed by integrating this curve graphically with respect to t.

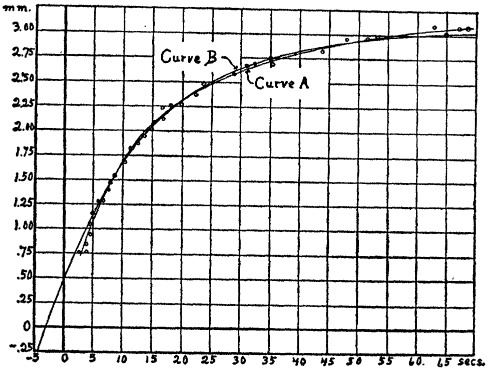

FIG. 2

TABLE II

	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	Distance in Mm.
1	2	4	7	11	16	22	30	42	Time in seconds.
2		2		5	7	10	15	21	
3	3	7	11	17	23	31	45	68	

The water in the ring has its maximum velocity just before the turn is completed. The time required to make a complete turn was three seconds, and if this is subtracted from the time in column 1, Table I., it gives the length of time between the completion of the turn and the first observation of the motion (column 4, Table I.). Now if a portion of Curve *B* (Fig. 2) be taken, such that the distance represented on the curve in the time of any particular reading is the same as the distance in that reading, the beginning of that portion of the curve will correspond to the time at which the motion of the globules was first observed (column 5, Table I.). So if the number of seconds in column four is subtracted from the time corresponding to the beginning of the reading, the time corresponding to the completion of the turn is obtained, and the velocity at that time can be read from the curve in Fig. 3. This value is given in column six, and is the velocity at the time of completing the turn. The velocities in each of the four cases are averaged separately, and the average of the four averages is taken as the true motion due to the earth's rotation.

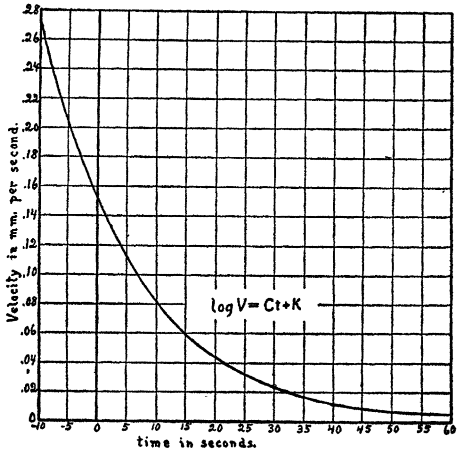

FIG. 3

The average of the velocities in these four cases is .0513 mm. per second. From the formula $V = \alpha r \sin \phi$ derived above, we obtain $V = .0484$, a difference of 5 per cent. As a check upon the accuracy of the readings, it will be seen that the differences between the velocities in Cases I. and II. and between those in III. and IV., representing double the velocity due to the difference in density of the water in different parts of the tube, are about equal; also the differences between Cases I. and III., and II. and IV., representing the variation due to imperfect adjustment of the axis, are approximately the same. In order to show that there was no appreciable effect from convection currents while the ring was in a horizontal position, several readings were taken after the tube had remained at rest for some time, none of which showed a motion larger than .015 mm. per second.

In order to obtain the best possible results, the ring should be mounted as rigidly as possible in a room of equal temperature throughout, and the axis should be capable of accurate adjustment parallel to the ring. If the radius of the ring were made smaller, although the effect of the earth's rotation would be less, it would be easier to keep all parts of the tube at an equal temperature, and the ring could be turned more quickly. Moreover, since the motion would not be so great, the velocity of the water would diminish less rapidly, so that more accurate readings could be obtained. With a more mobile liquid the motion would of course continue longer. Even with the comparatively crude apparatus described above, however, it is not difficult to show that the earth revolves.

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January 13, 1913

CROSSOPTERYGIAN ANCESTRY OF THE AMPHIBIA

For many years evidence has been accumulating for the view that the Amphibia have been derived not from Dipnoi but from Crossopterygians of some sort. Pollard[1] held that the Amphibia were remotely related to the living *Polypterus* and Baur[2] was able to strengthen the evidence, to some extent, from the Stegocephalian side. More recently Thévenin[3] has expressed similar views, while Moodie,[4] correcting Baur's observations on the lateral line grooves in the skull has seemingly demonstrated the general homology of the skull top of *Polypterus* with that of Stegocephalia. Gegenbaur[5] supported the homology of the Stegocephalian cleithrum with the "clavicle" of *Polypterus* and other fishes, while Klaatsch[6] showed that the pectoral limbs of *Polypterus* both in musculature and osteology in many respects remotely suggest Amphibian conditions. On the other hand, Goodrich's[7] studies on the scales of fishes, together with the evidence offered especially by the brain of *Polypterus,* tend to remove that genus widely from genetic relationship with the Amphibia.

The Paleozoic Crossopterygii have hitherto yielded a few, though significant, hints of Amphibian relationship. The Texas Permian Crossopterygian fish named by Cope *Ectosteorhachis nitidus* and recently figured by Hussakof[8] as *Megalichthys nitidus,* suggests remote Stegocephalian affinities in the skull and the same is true of *Rhizodopsis,* as figured by Traquair[9] and of *Osteolepis,* as figured by

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[1] ''On the Anatomy and Phylogenetic Position of *Polypterus,*'' *Zoöl. Jahrb. Abt. f. Anat. u. Ont.* (Spengel), V. Bd., Jena, 1892, pp. 387–428, Taf. 27–30.

[3] ''Les Plus Anciens Quadrupèdes de France,'' *Annales de Pal.* (Boule), tome V., 1910, pp. 1–64, pl. I.–IX.

[4] ''The Lateral Line System of Extinct Amphibia,'' *Journ. of Morphol.,* Vol. XIX., No. 2, 1908, pp. 511–540; 1 pl.

[5] ''Clavicula und Cleithrum,'' *Morphol. Jahrb.,* XXIII. Bd., Leipzig, 1895, pp. 1–21.

[6] ''Die Brustflosse der Crossopterygier,'' *Festschr. für Gegenbaur,* I. Bd., 1896, pp. 259–391, Taf. I.–IV.

[2] ''The Stegocephali. A Phylogenetic Study,'' *Anat. Anz.,* XI. Bd., 1896, No. 22, pp. 657–673.

[7] Cf. Lankester's ''Treatise on Zoology,'' Part IX., first fascicle. ''Cyclostomes and Fishes,'' by E. S. Goodrich, 1909, especially pp. 217–219, 290–300.

[8] ''The Permian Fishes of North America,'' Publ. No. 146 Carnegie Institution of Washington, pp. 168 and pls. 30, 31.

[9] ''On the Cranial Osteology of *Rhizodopsis,*'' *Trans. Roy. Soc. Edinburgh,* Vol. XXX., 1881.